320-2136A

MICROPHYSICAL STUDIES OF NOCTILUCENT CLOUDS

Final Technical Report

Contract Title:
"Microphysical Studies of Noctilucent Clouds"

Contract Number:
N00014-90-J-4046

Principal Investigator:
Dr. Bernard Vonnegut
State University of New York at Albany

Program Manager:
Dr. William A. Hoppel
Code 1241

Dr. Bernard Vonnegut, ES323
State University of New York at Albany
1400 Washington Avenue
Albany, New York 12222
518-442-4499

January 1992

MICROPHYSICAL STUDIES OF NOCTILUCENT CLOUDS

I. BACKGROUND

Very little is understood about the microphysics of noctilucent clouds. It is not known whether the ice crystals comprising them are of cubic habit, as has been suggested, or whether they are hexagonal, as in tropospheric clouds. It has not been established whether the crystal habit and the crystal growth rates are influenced or controlled by the nuclei present in the upper atmosphere, or whether temperature and humidity conditions play the dominant role in that respect as in the troposphere. It is clear, however, that the size and shape of the individual crystals determine their optical properties and therefore determine how noctilucent clouds interact with transmissions of electromagnetic waves.

Our experiments were aimed at revealing the habit of noctilucent cloud particles.

II. EXPERIMENTS AND RESULTS

The primary objectives of the investigation were to determine the habit of ice crystals formed at low atmospheric temperatures and pressures. An additional objective was to investigate what influence, if any, the presence of foreign substances, vapors and particulate matter, might exert upon growth rates and crystal habit. For this purpose it was attempted to modify and adapt well known techniques devised for studies of ice crystals under tropospheric conditions for use under noctilucent cloud conditions.

Our scheme was an adaptation of the conventional thermal diffusion chamber. Our chamber consisted of a glass tube containing a droplet of water,

evacuated and sealed at both ends. By application of heat to the end of the tube containing the water, supersaturation was obtained in the other end. Crystals could thus be nucleated in this part of the tube and grown to whatever size desired.

With the aid of a microscope we could watch condensation onto the capillary walls. Below temperatures of -20°C to -30°C, isolated, single crystals could be nucleated and grown to recognizable shapes, provided supersaturation was maintained low. Too high supersaturation resulted in nucleation of ice all over the capillary walls and the formation of a continuous sheet of ice. Commonly, isolated hexagonal bullets or plates could be observed.

At temperatures between -60°C and -70°C crystal habit could be perceived after a few hours of crystal growth. In this temperature range crystals exhibiting cubic or rectangular habits were frequently observed. Images of some of these were recorded on video. Figure 1 shows traces of such video images obtained at -30°C and -62°C. The former is cubic in shape; the latter hexagonal.

III. DISCUSSION

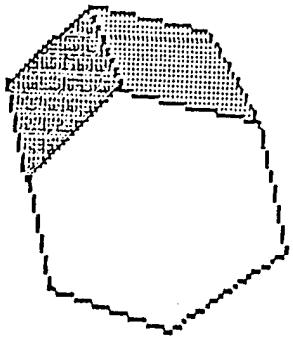
We conclude from our experiments that the ice particles present in noctilucent clouds may often exhibit cubic habit. It appears even possible that high tropospheric ice crystals may occasionally exhibit such habit. That would be consistent with rare, but reliable observations of the Scheiner's halo.

In the case of noctilucent clouds, however, it is doubtful that the crystal habit is after all of much practical importance, because due to low growth rates and limited duration of supersaturation at the mesopause, the crystals must be very small. Ice crystals of dimensions much smaller than the wavelength of

transmitted electromagnetic waves interact with the waves as Rayleigh scatterers, which allows for fairly simple theoretical treatments of the interactions. No refraction or surface reflection would be occurring. It appears that even after a few days of growth noctilucent cloud particles are still only a fraction of a micron in diameter. That is less than or equivalent to the wavelength of visible light.

Crystal Habits Observed in Low Pressure Chambers

1.

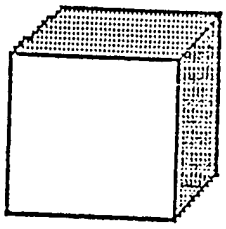


T = - 30C

Only hexagonal shapes are seen

2.

T = -62C



Cubic shapes are frequently seen

FIGURE 1

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FINAL REPORT
N00014-90-J-4046
TITLE: MICROPHYSICAL STUDIES OF NOCTILUCENT CLOUDS

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